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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the third year of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be used in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for a four-part unit which expands on the concepts about particles learned in ZIM-SCI units C1 ("What is Water?") and C2 ("Particles in Action"). Activities and experiments focus on: (1) elements, compounds, and mixtures; (2) particulate structure of matter and Brownian motion; (3) electrostatics and ions; and (4) chemical bonding. Since concepts in this unit cover requirements of the O-Level General Science Syllabus Examination, actual O-level examination questions are included. Each section in this guide corresponds to a given section in the student study guide. (JN)

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ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

YEAR 3

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'O' LEVEL TEACHER'S GUIDE

UNIT 2 ATOMS AND MOLECULES

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

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SEPTEMBER 1983

SYMBOLS

The following symbols will be used to indicate the points in the lesson at which teacher activity is particularly important. These symbols also appear at the corresponding points in the pupil Study Guides.

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.

Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.

Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.

This symbol appears at a point where it is necessary for pupils to think over what they have done in the past few lessons. Set aside a period for this review activity. Encourage the pupils to read over their notes and the study guide section which they have just covered. It may be helpful to ask them to write a summary too.

This symbol appears next to activities which are not experiments but involve pupils in observation and perhaps collecting information. An example is the field trip.

E.Q.

This symbol will appear where there are "Examination Questions" from past papers for pupils to practice answering. Model answers and explanations given in the Teacher's Guide.

This symbol indicates a cassette programme which will contain useful background information. The script for each programme is in the Teacher's Guide.

This symbol indicates a "Project". There is usually one at the end of every 'O' Level unit to give pupils a chance to apply their knowledge in a practical way.

The following symbols which appear only in the Teacher's Guide are used to indicate important points for you the teacher.

Take note of an important point.

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.

We have placed this symbol next to experiments where we feel there may be a possible danger. Please read the section carefully so that you know about the particular danger in that experiment. It would also be wise to refresh your memory on the appropriate safety or first-aid procedures described in the ZimSci Handbook.

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Exercises

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* Means Questions for this exercise written in the Study Guide and ONLY the ANSWERS are put in this Teacher's Guide.

Examination Questions - Model Answers

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Preparation Required Ahead of Time

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AIMS OF THIS UNIT

When pupils have completed this unit, they will be able to:

1. State the three states of matter.
2. Describe matter in terms of the Kinetic Theory.
3. Explain what happens when a chemical reaction takes place.
4. Describe the differences between an element, a mixture and a compound.
5. Explain diffusion.
6. Describe osmosis.
7. Explain the structure of an atom.
8. Explain the difference between electrostatic and current electricity.
9. Define:-
   - An electron
   - Proton
   - Neutron
   - Electron shell
   - Atomic number
   - Atomic mass
   - Valency
   - Isotope
   - Molecule.
10. Explain radiation in simple terms.
11. Read the Periodic Chart.
12. Explain Electrovalent or Ionic Bonding.
13. Explain Covalent Bonding.

ATOMS AND MOLECULES

CONCEPT DEVELOPMENT

This is the second unit in the O-Level series written for the A.E.B. Science Examination.

It extends the work covered in J.C to the work needed for the basic chemistry for the 'O' Level.

Its purpose is to build on what pupils have learnt about particles and expand it to the structure of the atom and the molecule.

The unit has been divided into 4 parts.

Part 1 which deals with elements, compounds and mixtures is mainly revision. Reference is made to the basic concepts taught in the Unit C1 (What is Water?) and C2 (Particles in Action) which deal with explaining matter in terms of particles behaviour. Experiments to show the differences between the three states of matter are co-opted from these units.

Separation of mixtures by chromatography (with paper) and its usefulness is discussed.

Part 2 of the unit deals with the particulate structure in matter and again is mainly revision of material covered in Unit C1 and C2. Reference is made to Brownian motion.

Here the idea of the behaviour of particles in motion is mentioned with reference to differences between solids, liquids and gases. The Kinetic Theory of matter is dealt with to explain diffusion of gases and liquids. Diffusion of liquids is then extended to cover osmosis and its applications.

Part 3 introduces a new concept, that of elementary electrostatics to get across the idea of matter being made up of tiny charged particles. A few experiments are carried out to determine the charge carried by the particles. Comparison is made between current electricity covered in Unit 11 and static electricity. The word electron is first mentioned and defined here. The material is then extended to cover the structure of the atom using a simple Bohr model of electrons going round the nucleus of the atom.

Protons and Neutrons are introduced.
Emphasis is laid on atomic number and mass number and how the different numbers of electrons, protons and neutrons give elements their characteristics. Students carry out experiments to help them discover the relationship between elements and how these elements are grouped together in families.

A simple classification key leads to the study of the Periodic Table of elements. A Periodic Table chart is included in the Study Guide and also a big chart of the Periodic Table to be hung in the classrooms is provided.

Radio-activity is discussed but not in great detail. The uses and hazards of radio-activity are discussed.

Part 4 of the unit deals with chemical bonding. A single treatment of electrovalent and covalent bonding is done. Experiments to show the characteristics of the two bonds are included in this part of the unit.

N.B

1. Exercises

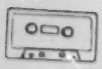
Most of the written exercises given in this unit will require as before the pupils to write their explanations in their own words rather than "filling in the blank" style exercises. This will allow them to develop their writing skills.

E.Q.

2. Examination Questions

These are real examination questions out of past A.E.B. 'O' Level General Science papers so that pupils can test their knowledge straight away against examination standard questions. PLEASE DO NOT LET PUPILS WRITE THEIR ANSWERS IN THE STUDY GUIDES. The spaces left under the questions are just to show that in the real exam there is space on the paper where they will put their answers.

This Teacher's Guide provides model answers to all the examination questions as well as explanations as to how these answers are arrived at.



3. Cassette Programme

The script for cassette programme for this unit is at the end of the unit. You should play the cassette when you have been through the Unit. Discussion should follow the cassette programme.

4. Project

This is a chance at the end of the Unit for the pupils to apply the knowledge they have gained in a practical way.

For this particular unit models could be made from wet clay or any other material that is easy to model.

P

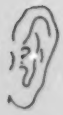
5. Special Apparatus

Before you start teaching the Unit make sure you have collected at least 20 glass jam jars. You need these later for the experiments in the Unit. You can ask pupils to bring these.

PART 1

Elements, Compounds and Mixtures

Revise with the class what they know about elements, compounds and mixtures.
Pupils should be able to tell you at this stage that:-



Elements

1) are made of the same kind of atoms

2) cannot be split into simpler substances by chemical means

3) when an element undergoes chemical change it can gain or lose mass by joining with another element to form a compound.

Mixtures

1) the substances can be separated by physical means

2) mixtures can have a varying composition

3) the properties of a mixture are the same as the properties of its constituents

4) usually there is no change in mass or evolution of heat on mixing.

Compounds

1) can only be decomposed (split) by chemical means

2) have a constant composition

3) the properties of a compound are different from the properties of its constituent elements

4) usually there is a change in mass and heat is either given out or absorbed when a compound is formed.

Exercise 1 page 1

Write the questions on the board and let the pupils copy and answer the questions that follow into their exercise books.

Questions

1. 10g of a white solid are dissolved in water. When the solution is concentrated, by heating, crystals of the solid are formed. These crystals are removed by filtration, dried and weighed. Their mass is 7g.

   Which of the two statements below is correct? Explain your answer.

   A: A chemical change has taken place as there is a loss in mass.
   B: A physical change has taken place as the same substance has been obtained.

2. When crystals of copper nitrate are heated in an evaporating dish, a brown gas is given off and a black powder is left. Which of the two statements below is correct? Explain your answer.

   A: The mass of the black powder is the same as the mass of the copper nitrate since the powder came from the crystals.
   B: The mass of the black powder is less than the mass of the copper nitrate crystals.

Answers to Exercise 1.

1. B is correct.

   Although 7g of crystals were obtained, the remaining 3g of the white solid remained in solution. Forming a solution and crystallising it are physical changes. There is no true loss in mass by the substance because if the solution was evaporated to dryness the 3g of solid would be left. Therefore 3g + 7g = 10g.

   A is wrong because there is not true loss of mass of solid. No new substances were formed.

2. B is correct.

   Chemical decomposition has taken place as two new substances, a brown gas and a black powder are formed. The copper nitrate crystals will then have lost mass. The black powder remains, so its mass must be less than that of copper nitrate.

   A is wrong because of the explanation given for B. The mass of the powder plus the mass of the gas given off would equal the mass of the crystals.

Activity 1 page 1 : To extract chlorophyll

Try this activity yourself first.

The leaves need to be ground thoroughly. Geranium leaves are best for this because they are rich in chlorophyll. Use soft fleshy leaves.

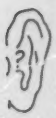
On heating the methylated spirit in the tin, make sure that the pupils take great care not to overheat the contents or to let naked flame reach the methylated spirit as it catches fire readily.

Experiment 1 page 2 : Chromatography

The peg is there to prevent the strip of filter paper touching the sides of the plastic bottle as you can see from the diagram in the Study Guide.

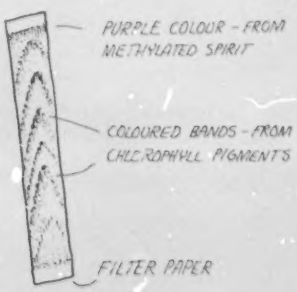
As long as the chlorophyll extract is concentrated on the strip of paper and the set-up is not disturbed, pupils should be able to get clear separation of pigments as evidenced by the colours that appear on the paper as the solvent moves up that paper.

These colours can be seen clearly in a bright light.



In this experiment, 3 distinct pigments in the chlorophyll are separated out by the solvent from the chlorophyll line on the filter paper as follows:

i) Chlorophyll A is a bluish band.
ii) Chlorophyll B is a yellow-greenish band.
iii) Carotene appears yellow.
iv) Purple is from the methylated spirits.



This means then that the green chlorophyll is a mixture of the 3 above pigments and in this experiment we have succeeded in separating them. The bands can be separated by cutting them out from the filter paper. There are other chromatographic techniques beside the one described in Experiment 1. One of the simplest methods is to separate a grass extract using blackboard chalk. A little grass extract is placed in a small dish, and a stick of blackboard chalk (white) is stood on end in the extract. The liquid will be drawn up the chalk and coloured bands of the various components will be formed in the chalk.

Other chromatographic techniques are thin layer chromatography and gas chromatography which is used a lot in industry to separate volatile liquids.

Other substances that can be separated by chromatographic technicues are:

i) inks of various kinds
ii) indicators, e.g. universal indicator
iii) mixtures of various hydrocarbons, e.g. a mixture of petrol diesel and paraffin.
iv) proteins.
v) bile pigments.

Particulate Structure of Matter. page 4

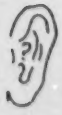
Experiment or activity to show that matter is made up of very small particles. You can remind the pupils of the following experiments:

1: Dyestuff Dilution Experiment Unit C1 page 7.
2: Dissolving copper sulphate Unit C1 page 8.
3: To find out how fast ammonia particles diffuse in air Unit C2, page 27.

Experiment 2 : Placing methylated spirit on a hand page 8

One drop of methylated spirit on the back of the hand is all that is needed for this experiment.

This experiment works much better with other volatiles e.g. acetone, alcohol e.g. ethanol or propanol. The methylated spirit works quite well as long as there isn't too much water in it.

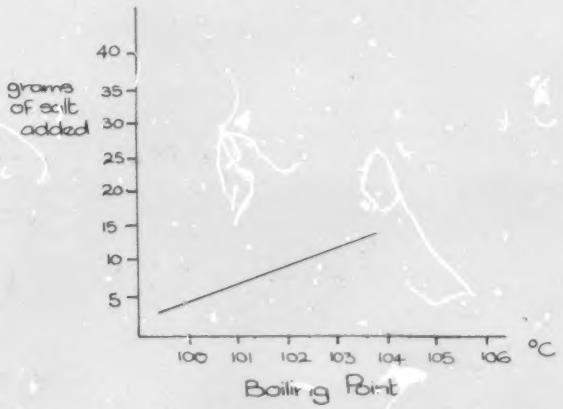


In order for the liquid to evaporate the molecules making the liquid have to gain more Kinetic energy so that as they move faster and faster some escape into the air from the liquid and are lost. This extra energy is taken as heat energy from the skin by those molecules of the liquid in close contact with the skin. As these molecules start moving faster the energy is transferred to other molecules through collision with adjacent molecules until the molecules at the surface of the liquid are themselves having greater kinetic energy and so can escape into the air. This happens until all the liquid is evaporated. The spot where the liquid was felt cold because of the heat removed by the molecules of the liquid as they gained more kinetic energy.

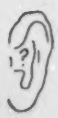
Experiment 3 : Determining the boiling temperature of salted and unsalted water. page 8

In this experiment it will not be possible to get the plain water to boil at 100°C as the boiling point depends on a number of factors e.g. purity, altitude or pressure (Zimbabwe being above sea level). What conclusion can one draw from the experiment then?

Let the pupils plot the results of their experiments on a graph using concentration/boiling point as axes.



From the results it is clear that the rise in the boiling point of water is directly proportional to the concentration of salt in the solution, since for each 5 grammes of sodium chloride added the boiling point is raised by 0,5°C.



In the cold countries of Europe and North America, sea water is much less readily frozen than fresh water. In cold weather adding salt on frozen roads causes ice or snow to melt at temperatures not too far below 0°C. As a result the roads are defrosted. The melting point and boiling point of a substance are two of its physical properties i.e. those which affect sight, hearing, taste, smell and touch. Colours and smells (ammonia experiment) are readily observed. Tasting is less useful because an unknown substance may be poisonous or cause burns. Those properties which can be measured exactly are most useful and they include melting point and freezing point, boiling point and density. These are physical properties or characteristics.

For example a colourless, odourless liquid may be water. If it freezes at 0°C, boils at 100°C at sea level and has a density of 1g/cm^3 at 4°C it is definitely water.

E.Q.

Page 10 Examination Questions

When your pupils try out the examination questions it is important, right from the beginning, to make sure that they develop proper examination technique. You must stress two points.

Firstly READ the question carefully and give only the answer asked for. After the pupil has got the marks for the right answer, any extra writing by him/her is a waste of time because there are NO marks given for it.

Secondly, pupils must write the whole answer. The examiner will give no marks for answers not written down!

Therefore when we give you a model answer ONLY the part written *like this* is needed to answer the question and get full marks. Everything else is background material to help you explain the answer to the pupils, if necessary.

Each question given here is worth about 5 marks. Your pupils will need to work at a rate of about 1 mark per minute so each question should take them only about 5 minutes.

Answer 1

(a) *Molecule X has the higher boiling point because it is a larger molecule.*

Note that molecule X has 9 carbons to 5 of molecule Y. Molecule X is called Nonane and molecule Y is Pentane. The higher the number of carbon atoms the higher the boiling point because it has a larger mass so needs more energy to have the molecule escape. (It needs more energy to move a large rock than a small one).

Example of Boiling Points of hydrocarbons.

Up to 200°C	Naptha	C_5H_{12}- $C_{12}H_{26}$
200-260°C	Kerosene	$C_{12}H_{26}$ $C_{15}H_{32}$
260-300°C	Gas-oil	$C_{15}H_{32}$- $C_{17}H_{36}$
Above 300°C	Fuel-oil	$C_{17}H_{36}$

(b) *A mixture is a substance made of two or more substances not joined together chemically while compounds are substances made of two or more elements joined together chemically.*

NOTE a mixture can be separated by physical means while a compound can only be separated by chemical means.

Answer 2

(a) *In molten chloride no sodium particle is attracted to chloride particles so the particles are free to move around; as a result molten sodium chloride has no rigid structure.*

The bonds in solid sodium chloride are rigid and strong; as a result the particles vibrate in one place instead of moving around.

(b) *More heat is needed because molten sodium chloride will be changing state to sodium chloride vapour.*

NCTE that this extra energy in the form of heat is called latent heat of vaporisation. There won't be a temperature rise as the liquid is changed to gas. The extra heat is used for this purpose.

Answer 3

(a) *Brownian Motion.*

(b) *The smoke particles are being bombarded (hit) constantly by air molecules.*

(c) *Convection.*

EXPERIMENT 4 : OSMOSIS page 12

Ask the pupils to bring a fresh egg each. 2 pupils can work with 2 eggs. If you eat eggs yourself for breakfast make sure you break them in such a way that you'll be able to use the shells for the experiment. Keep the shells moist. The egg contents can be collected and eaten later. The egg shell can be kept for a day.

A ratio of 3 sugar to 5 water should giveyou a good concentration of sugar, but if the experiment is slow to work, you can add another measure of sugar to make a stronger solution.

The conclusion is that the water molecules move across the semi-permeable membrane from a region of high water concentration to a region of low water concentration. The egg membrane has very tiny holes which only allow small water molecules to pass through it and not larger sugar molecules.

Exercise 2 page 15

1. If you were given a mixture of two liquids, ether and acetone, having boiling points respectively of 35°C and 56°C, describe in full how you would go about separating them in order to get a pure specimen of each.

2. Iodine crystals dissolve in liquid A (a complex organic compound) very well, but are only slightly soluble in water. Common salt dissolves very well in water, but does not dissolve in this liquid A. Copper filings do not dissolve in liquid A or in water. How would you obtain a pure crystal of salt from a mixture of iodine crystals, salt crystals and copper filings?

ANSWERS TO EXERCISE 2 page 15

1. You would separate the two liquids by fractional distillation. ther would be collected, as a distillate, at 35°C. When all the ether had been collected, the temperature would be raised until the distillate reached 56°C. The intermediate (middle) product would be discarded. The acetone would be collected at 56°C.

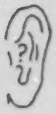
2. You would dissolve the mixture in liquid A, then filter off the copper filings and salt crystals. At this stage the filtrate will contain only dissoved iodine. Next, dissolve the residue (copper filings and salt crystals) in water; filter the solution again to remove the copper filings. Evaporate the solution to dryness, that is, crystallise the salt from the solution.

EXPERIMENT 5 : Electric Charges page 16

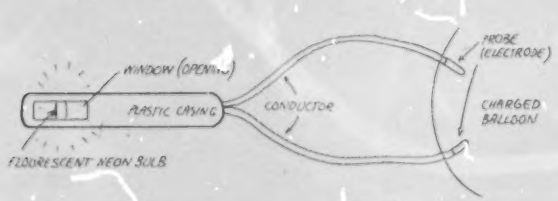
Make sure that the pupils rub both the plastic pen and inflated balloon well with a woollen cloth. Pupils jersey's or hair will charge the balloon and the pen well.

Activity 2: .5 Use a Fluorescent Neon-Bulb Tester page 18

This activity needs 2 pupils.
One holding the inflated and charged balloon and the other the neon-bulb tester. The pupil holding the balloon should rotate it as the conductor ends are brought to touch the charged balloon. The neon-bulb should flash a couple of times as the balloon is rotated. Even if its only one conductor end touching the balloon the pupils should get a result. To see the flash clearly you need a dark background or darkroom in addition the balloon must be well charged



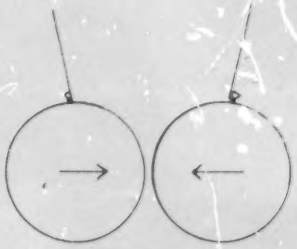
The bulb flashes as the balloon is rotated because lead or conductor ends picks up negatively charged particles - ELECTRONS - from the balloon and these are conducted by the lead through the bulb which then flashes like any other torch bulb.



This Activity is to show that the particles responsible for static electricity are the same as those that are involved in current electricity, these being electrons. Therefore static electricity is real electricity.

EXPERIMENT 6: To Show Attraction page 19

If the one of the the two balloons is well charged and both are hanging freely the pupils shouldbe able to see an attraction between them.



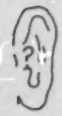
ATTRACTION

EXPERIMENT 7: To Show Repulsion page 20

This time both balloons are well charged with the same material e.g. woollen cloth and again are hanging freely the pupils should be able to see repulsion between them.

REPULSION

Pupils should repeat the 2 experiments above until all are satisfied that attraction and repulsion is taking place. It is best to carry out the two experiments in a draught-free environment as the wind can distort the results.

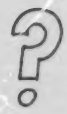


In Experiment 6 when one of the balloons is charged it means that that balloon carries an exess of charges on its surface.

These may be negative charges or even positive charges depending on the material used to charge them. If the charged balloon is carrying negative charges and is brought to an uncharged balloon that uncharged balloon acts as a positive pole so there will be attraction between them like opposite poles of magnets do.

However, if both balloons are charged with the same material both balloons will carry similar charges therefore when brought together they will repulse each other like similar poles of magnets do.

By these 2 experiments you are trying to show that frictional force confers charges be they negative or positive charges on objects.



ANSWERS TO HOW MUCH DO YOU KNOW? page 22

1. Move.
   Semipermeable.
   High water concentration.
   Low water concentration.
   Osmosis.

2. Diffusion.

3. Water.
   Mineral salts/plant nutrients/very small molecules/ions.

4. Static electricity.
   Current electricity.

5. Force.
   Move.
   Conductor/wire.
   A cell/battery.

6. Friction.
   Rubbed.

7. Attract.
   Repel.
   Negatively.

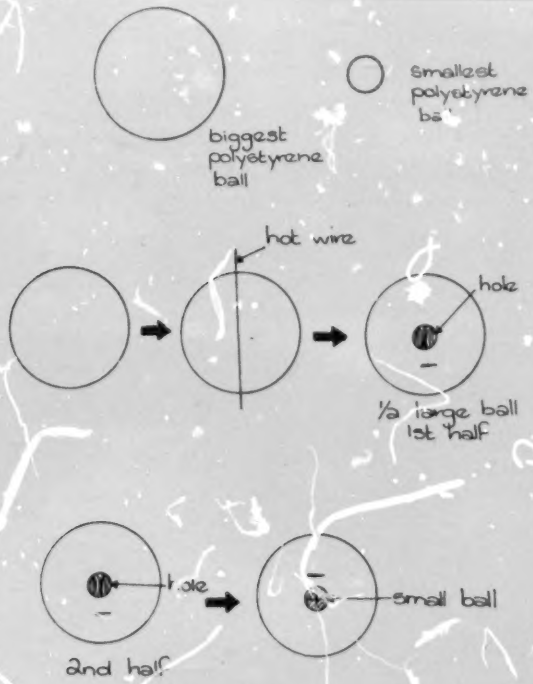
8. Positively.
   Attract.
   Negatively.
   Uncharged.

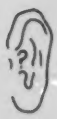
9. Electron.

10. Electron.
    Negatively.

MODEL OF AN ATOM page 23

In the kit are two sizes of polystyrene balls. One large white one the size of an orange, the other a small coloured one.
Using a hot piece of wire or hot knife cut the large ball into 2 halves.
Gorge out the centre of the 2 halves so that the small polystyrene ball fits in nicely as the seed of an avocado pear does.
(You can do this before the lesson starts.)

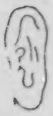




Now show the class the large ball and tell them that an atom would resemble something like the large ball (round). Open the ball to show the two halves with the small coloured polystyrene ball in the centre.

You can then explain the structure of the atom to the class using this model. The small coloured ball would represent the nucleus of the Atom and the rest of the large white ball would represent the electron shell(s) or cloud(s) through which the electron(s) is/are moving round the nucleus. Notice the size of the shell(s) as compared to the size of the nucleus of the atom.

The diagram of the football pitch on page 24 is meant to show the relative size of the nucleus in an atom compared with the total size of the atom. Make sure the pupils do not confuse the nucleus in an atom with the nucleus in a cell. Tell them that the nucleus is usually the central part or thing round which others are collected.



Helium has atomic number of 2 i.e. has 2 protons and 2 electrons. It has a mass number of 4. The whole mass of the atom is contained within the nucleus therefore if the 2 protons in the nucleus give a total mass of 2, there must be a further mass of 2 present in the nucleus. Where does this extra mass come from?
The answer is that this extra mass of 2 comes from 2 other particles present in the nucleus of the helium atom. These particles having a mass of 1 each are called Neutrons.

All elements have neutrons in the nuclei of their atoms except Hydrogen (gas) whose atoms do not possess neutrons in their nuclei.

Exercise 3 page 28

Answer the following questions in your exercise books.

1. Given that the sodium metal has 11 protons in each of its atoms, how many electrons are there in each of its atoms?

2. What is the atomic number of sodium?

3. Silicon has 14 protons, what is its atomic number?

4. The atomic number of calcium metal is 20.
How many electrons does each atom of calcium have?

5. Iron has an atomic number of 26.
How many protons does each of its atoms have?

6. Beryllium has a mass of 9 and atomicnumber of 4.
How many neutrons does it have?

Answers to Exercise 3 page 28

1. 11 electrons.

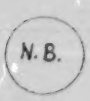
2. 11

3. 14

4. 20 electrons

5. 26 protons

6. 5 neutrons.



* ERRATA page 29

Please have pupils correct the fourth line from the bottom of the page to read:
However, a lithium atom with its atomic number of 3 has a mass of 7 therefore it must have 4 neutrons.

Tell the pupils the following:-

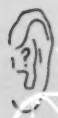
NOTE that the number of neutrons in the nucleus of the atom does not always equal the number protons present in that Atom. Some elements have the same number of protons as neutrons in the nuclei of their atoms e.g. Magnesium has 12 protons and 12 neutrons. Helium has 2 protons and 2 neutrons, but Bromine has 35 protons and 45 neutrons and Zinc has 30 protons and 35 neutrons.

ISOTOPES page 32

Most elements have isotopes. Besides hydrogen and oxygen mentioned in the Study Guide, others are carbon whose atomic number is 6 but can have a mass of 12 or 14. Therefore carbon 12 and carbon 14 are carbon isotopes.

Chlorine has 2 isotopes one with 18 neutrons, the other with 20 neutrons. The relative atomic masses of the two isotopes are Chlorine 35 (17 protons + 18 neutrons), Chlorine 37 (17 protons + 20 neutrons).

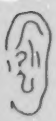
The average relative atomic mass of ordinary Chlorine 35,5. (It's not 36 because ordinary Chlorine has more Chlorine 35s than 37s.)



Remember an isotopic element is one that has its atoms consisting of different numbers of neutrons.

We will discuss the usefulness of isotopes later in the unit when we talk about radio-activity.

PERIODIC TABLE OF ELEMENTS page 33



Lead the discussion here on classification of objects in general, based on shaped, colour, durability, texture and try and link this to the common elements pupils are familiar with. At the end pupils should form an opinion that elements like most other things could be classified according to how they look or feel.

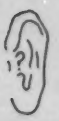
Activity 3 page 33 : Classification of metals and non-metals.

Pupils should be able to classify these elements easily by the use of their physical characteristics. They should be able to put copper, magnesium, iron and lead into one group and iodine, carbon and sulphur in another. They may have difficulties with calcium metal.

EXPERIMENT 8 . Reaction of Metals with Water. page 33

Pupils have done this kind of experiment before in Unit F2.

The idea in this experiment for the pupils to discover that some metals do react with water fast to produce hydrogen while others do not. Therefore separation of the metals can be done on this chemical property. Pupils should be able to get a reaction with calsium easily.
Magnesium will react with very hot water or steam but, very, very slowly with cold water.
Copper and lead do not react with water at all to produce hydrogen.



The universal indicator paper will show the presence of a hydroxide in the residue when calcium has been reacted with water.

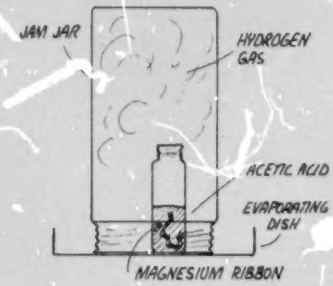
calcium + water ⟶ calcium hydroxide + hydrogen.

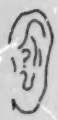
$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$.

NOTE warn pupils not to splash calcium hydroxide as it burns.

EXPERIMENT 9 : Reaction of Metals with Dilute Acid page 34

Again pupils have done this kind of experiment before in Unit F2 when they reacted hydrochloric acid within a piece of magnesium to produce hydrogen gas. In this experiment we have used acetic acid because its safer to react calcium with acetic acid than with dilute hydrochloric acid. The reaction is slower with acetic acid.





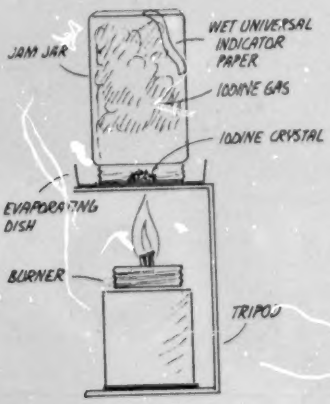
Both calcium and magnesium will react with the acid to produce hydrogen. Copper and lead will not. From these 2 experiments pupils should form an opinion that calcium and magnesium, though they don't look the same in fact do belong to the same group of metals. Copper and lead belong to another group.

EXPERIMENT 10 : Heating sulphur, carbon and iodine. page 35

This is the first of the experiments in this Unit when you need to use those jam jars which you and the pupils had earlier collected. The jam jar is to enable the pupils to see the colour of the gases or fumes produced and also to contain these so that the fumes don't spread and fill the classroom with unpleasant gases. Warn the pupils not to directly inhale these gases as they may be poisonous. These experiments would be better done outside but if done inside open all windows and doors.
Use only a tiny crystal of iodine.

Through this experiment pupils should discover that although all are not metals, they produce gases when heated but these gases react differently to a wet universal indicator paper. The sulphur produces an acidic oxide gas while iodine does not.

Therefore non-metals just like metals can be separated into different groups on this characteristic.



PENDULUM page 36

Tie a string through the hole of the 5g mass from the Kit.

Swing mass so that the pupils see how a pendulum operates and how it shows a period of time.

Group I Elements.

Characteristics of these elements can be divided into 2 categories:

Physical Properties

These metals not only have high densities but also all

are soft metals;

have low melting points below 100°C;

have high electrical conductivities.

Chemical Properties

- High reactive metals;

  reactivity increases with increased atomic mass of the element;

- the valency number is one. They all ionise by the loss of one electron per atom;

  $Na \longrightarrow Na^{+} + e^{-}$ (K similar);

- they are easily oxidised, therefore are good reducing agents;

- sodium and potassium form strong basic oxides which react with water to form strong alkalis, sodium hydroxide and potassium hydroxide respectively.

Group II Elements.

These are the Alkaline Earth Metals.

- They are harder, more dense (than Group 1 Elements);
- they have close-packed crystal structures;
- all have a valency of 2;
- they are readily oxidised;

  metallic calcium is a powerful reducing agent;

- they form basic oxides which, when dissolved in water, form alkalis, e.g. calcium hydroxide and magnesium hydroxide.

EXPERIMENT 11 : Reacting Magnesium with Iodine. page 38

In this experiment make sure that the pupils don't overheat their parcel otherwise a lot of iodine fumes will escape from the parcels and fill the room.

AS AN EXTRA PRECAUTION INSTRUCT THE PUPILS TO PLACE A JAM JAR OVER THE PARCELS TO BE HEATED.

When the parcels are opened the pupils should be able to discover that the shiny metallic lustre of the magnesium metal has disappeared and a yellowish brown colour is now present. The yellowish brown material on the magnesium ribbon is none other than a compound magnesium iodide which is a salt.

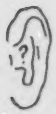
Magnesium + Iodine ⟶ Magnesium Iodide

Mg I_2 MgI_2

Halogens also form a reactive series, with fluorine the most active followed by chlorine and astaline being the least active.

EXPERIMENT 12 : Reacting Iodine with Hydrogen. page 39

In this experiment pupils have to produce hydrogen gas first as they have done in an earlier experiment with magnesium acetic acid. Before they start placing the jam jar of the small plastic bottle with acetic acid and the magnesium ribbon, they should place a wet universal indicator paper in the jam jar.



Hydrogen is very light so it should fill the jam jar and the pupils would not lose much gas as they place the jar over the small crystal of iodine.

Heating the iodine crystal gently will produce iodine gas which will react with the hydrogen gas already in the jar to produce an acid gas, hydrogen iodide.

Hydrogen + Iodine ⟶ Hydrogen Iodide

H_2 I_2 2 HI (gas) Acid

Activity 4 : To examine solutions of compounds of Transitional Elements. page page 41

Make solutions of the following compounds and show these to the class i.e.

1. copper sulphate
2. copper hydroxide carbonate
3. potassium permanganate
4. potassium chromate.

Pupils should be able to see the solutions have brilliant colours. This is one property of transitional elements. The transitional elements have coloured ions and these show well in solution.

Put on the board a table to show the transitional compound, the colour of the solution and the transitional ion responsible for the colour. e.g. (see table)

Compound	Colour	Ion responsible for Colour.
Copper sulphate	blue	Cu^{2+}
Copper hydrogen sulphate	green	Cu^{+}
Iron III chloride	yellow	Fe^{3+}
Potassium chromate	blue/green	Cr^{+}
Nickel bromide	green	Ni^{2+}
Potassium permanganate	blue/purple	Mn^{2+}
Cobalt chloride	pink	Co^{2+}

Because the ions from the transitional elements are coloured most of them are used in the dye and paint manufacturing industries.

PERIODIC CHART page 41

Hang the chart on the wall of the classroom. This chart has more detail than the chart in the Study Guide. For example there is complete electron configuration layout for each element.

Let the pupils copy this chart into their exercise books during their free time.
When discussing the elements you can always refer the pupils to this chart.

However, pupils are only expected to know the atomic structure of the first 20 elements.

Elements of Group VIII page 41

Pupils should be able to notice from the chart that the valency shells of all the elements in this group have 8 electrons (stable Octet). This explains the inactivity of these elements.

E.Q.

Answers to Examination Questions page 42

1. (a) *X is a Neutron.*
Y is a Proton.
Z is an Electron.

(b) *Electrovalent bonding.*

2. (a) i. *12 Neutrons.*
ii. *11 Electrons.*

(b) *The particles of sodium in sodium chloride are positively charged i.e. have electrons missing.*
This is so if the sodium chloride is molten or in solution, in a neutral atom the electrons ballance the protons.

(c)

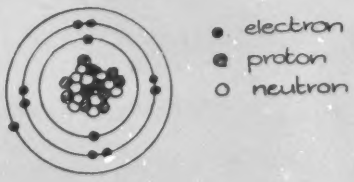
	1st shell	2nd shell	3rd shell
Number of Electrons in	2	8	1

d) *An atom has a nucleus consisting of protons and neutrons (except hydrogen) and shells made up of electrons going round the nucleus.*

The atom is supposed to be spherical with a centre consisting of positively charged particles - protons and neutral particles - neutrons. Surrounding the nucleus is the electron cloud (s)

3. a) *The number electrons balance the number of protons in the nucleus of the atom.* In an ion the number of protons and electrons do not balance. An ion is an atom that has lost an electron or electrons (one or more electrons).
b) *It would have neutrons in the nucleus.*
c) *It would become an ion of a different atom.*

4. a) diagram



b) *A metal, because the valency shell contains only one electron.*

There is no non-metal with eleven protons. Neon has 10 protons and the next non-metal after neon is silicon with 14 protons.

RADIO-ACTIVE ELEMENTS page 44

All those elements past Bismuth to Lawrencium on the Periodic Chart including the Lathanide series and Actinide series are rare and are radio-active. Most of these elements have heavy and complete nuclei which prevent them from existing as entire atoms. All have large atoms whose mass is concentrated in the nucleus.

* NOTE - Radio-activity can also be spelt Radioactivity with no hyphen between radio and active. Both are correct.

Activity 5 : Making a model of half-life of an element. page 46

For this model you need bags of 5g masses. Each bag of masses represent a radio-active element and the 5g masses inside the bag represent atoms of that element.

In a two minute period, the following should be done:

Each pupil must spin or throw his/her mass into the air.
It must be left to settle then noted whether the plain side or the side marked 5g is upper most (facing upwards).

Those masses show which 5g mark must be considered to have "decayed" and should be put aside.

FRONT

Count the number of plain-sided ones left and make a note of them on the board. In the next of the 2 minute period, the pupils who had the plain-sided masses should REPEAT the spinning and let the masses settle again.

BACK

As before, count the plain-sided masses and put aside or discard the 5g masses, record the number of the plain-sided masses on the board. Keep doing this every 2 minute period until there are no more plain-sided masses left or showing.

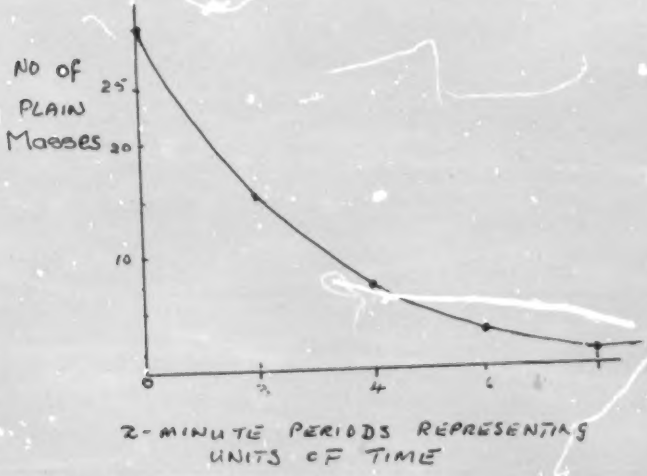
You should now have a record on the board of how many plain sided masses were left for each 2 minute period as the pupil carried out the activity.

Using these 2 columns of figures you should construct a graph on the board using the following axes:

Vertical axis - No of plain masses.
Horizontal axis - 2 minute periods representing units of time.

Join all the points to complete the graph.

When you have joined all the points your graph on the board should look like this:



All radio-active elements show a half-life graph like the one you have just constructed on the board as they decay
* Decay is random not exact.

Radio-activity can be induced artificially into some elements by bombarding their nuclei with neutrons or beta particles thereby changing completely the nature of one element because the proton leaves the atom thereby changing its atomic number.

Sulphur bombarded with a neutron will result in phosphorus plus one proton.

We can write the above in a symbolic equation like this:-

$$^{32}_{16}S + ^{1}_{0}N \longrightarrow ^{32}_{15}P + ^{1}_{1}P$$

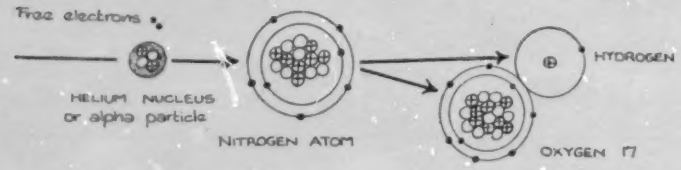
Sulphur 32 + 1 neutron will give phosphorus 32 + 1 proton particle.

The same is true of nitrogen.

If an atom of nitrogen is subjected to alpha particles it will produce oxygen and 1 proton.

$$^{14}_{7}N + ^{4}_{2}H \longrightarrow ^{17}_{8}O + ^{1}_{1}P$$

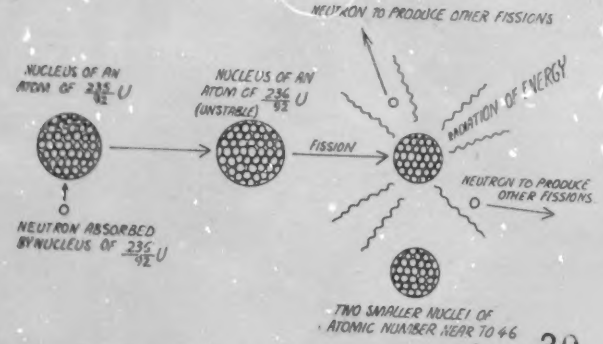
Nitrogen 32 + 1 helium ion will produce oxygen 17 plus 1 proton particle. We call this process ATOMIC TRANSMUTATION. i.e. changing one element to another.



The atomic nucleus of the isotope uranium, $^{235}_{92}U$, could absorb a neutron and then break into roughly equal parts. This process of splitting up of the atom is called ATOMIC FISSION.

The result of this process of fission is that the total mass of the products of atomic fission is slightly less than the total initial mass. The difference of mass is given out as energy.

The process of fission also emits more neutrons which can proceed to bombard the nuclei of more uranium atoms resulting in more amount of energy and further neutrons. The process then becomes a chain reaction.

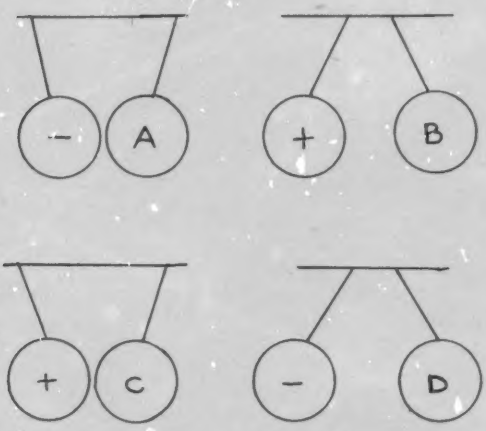

NEUTRON TO PRODUCE OTHER FISSIONS
NUCLEUS OF AN ATOM OF $^{235}_{92}U$
NUCLEUS OF AN ATOM OF $^{236}_{92}U$ (UNSTABLE)
FISSION
PORTION OF ENERGY
NEUTRON TO PRODUCE OTHER FISSIONS
NEUTRON ABSORBED BY NUCLEUS OF $^{235}_{92}U$
TWO SMALLER NUCLEI OF ATOMIC NUMBER NEAR TO 46

The energy liberated from atomic fission can produce a tremendous explosion if it is not controlled. Heat generated from such an explosion can be in millions of degrees celcius. This energy from Atomic fission can be harnessed and used to power nuclear submarines or to power Atomic Power Stations which generate electricity. Atomic bombs also use the concept and principles of nuclear fission.

Exercise 4 page 48

1. Look at the drawing of balloons hanging on strings below. State whether each lettered balloon has a positive + or negative -ve charge.

   A ....., B ....., C ....., D .....



2. What are protons, neutrons and electrons?

3. Explain:
   (a) two ways in which an electron is different from an atom.
   (b) two ways in which an electron is different from a proton.

4. If you are told that an atom has 16 electrons:-
   (a) What is the atomic number?
   (b) How many shells of electrons will it have?
   (c) What is its electron configuration?

5. An atom has 1 electron in its fourth shell. All the first 3 shells are full.
   How many protons has it got in its nucleus?

6. An atom of a metal Zinc has 30 protons in its nucleus. The first 3 shells are full. Draw the atom.

7. For the following atoms fill in the missing figure as the example shows.

	Protons	Neutrons	Electrons	Mass Number
Atom A	3	2	3	5
Atom B	5	-	-	10
Atom C	6	-	-	12
Atom D	-	13	-	25
Atom E	-	-	15	31
Atom F	-	5	7	-

8. Given that element:-

X has a half-life of 100 years
Y has a half-life of 24 days
Z half-life unknown

Show graphically

(a) what the original mass of element X would be if it decayed to 6,25 g in 400 years.
(b) how long it would take 16 g of element Y to decay to 1 g.
(c) what mass of element Y would be left after 144 days.
(d) what the half-life of element Z would be if it took 10 g of the element to decay to 7,5 g in the first 1,25 minutes and had further decayed to 5g in the next 1,25 minutes; in a total time of 5 minutes the element had decayed to 2,5 g and finally by the time its mass wass 0,625g a total time of 10 minutes had elapsed.

Answers to Exercise 4 page 48

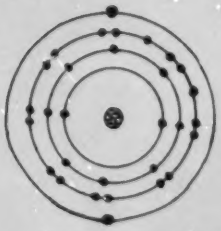
1. Balloon A +ve, Balloon B +ve, Balloon C -ve, Balloon D -ve.

2. Protons are +vely charged particles found in the nucleus of an atom. Neutron energy particles that carry no charge and are found in the nucleus of an atom.

3. (a) (i) An electron is negatively charged while a neutron carries no charge.
   (ii) The mass of electron is negligible compared to that of a neutron.
   (b) (i) A proton is positively charged while an electron is negatively charged.
   (ii) The mass of an electron is negligible compared to that of a proton.

4. (a) 16
   (b) 3 shells
   (c) 2/8/6.

5. 29 protons.

6. 

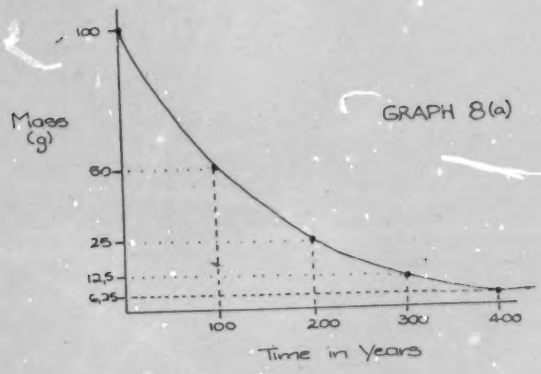
Zinc Atom 2/8/18/2

Zinc atom 2/8/18/2.

7.

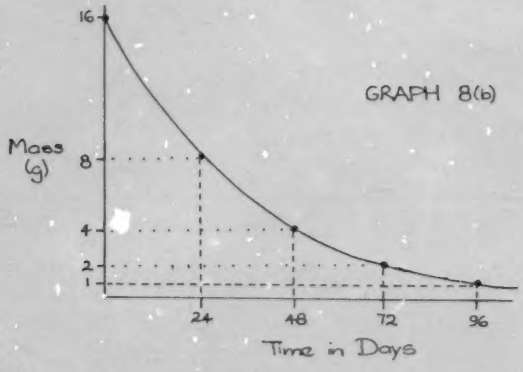
	Proton	Neutron	Electron	Mass Number
Atom A	3	2	3	5
Atom B	5	5	5	10
Atom C	6	6	6	12
Atom D	12	13	12	25
Atom E	15	16	15	31
Atom F	7	5	7	12

8. (a) 100g



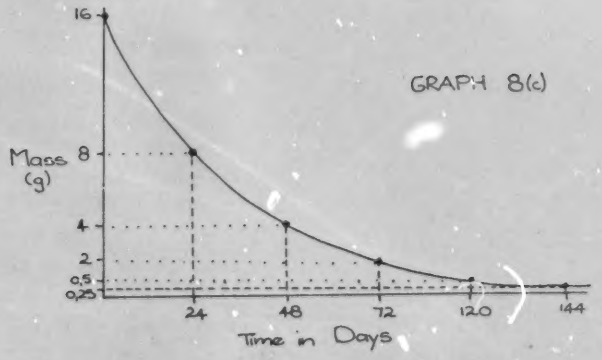
GRAPH 8(a)

(b) 96 days.



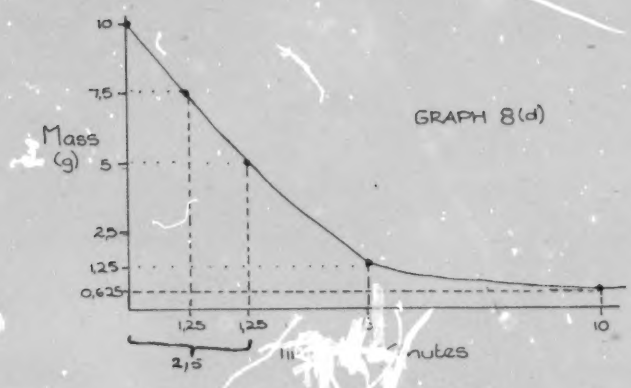
GRAPH 8(b)

(c) 0,25g



GRAPH 8(c)

(d) 2,5 minutes



CHEMICAL BONDING page 49

Besides the 2 chemical bonds mentioned i.e. Electrovalent/Ionic and Covalent bonding, there exists in chemistry other types of bonds. You don't need to teach these. These are for your information only.

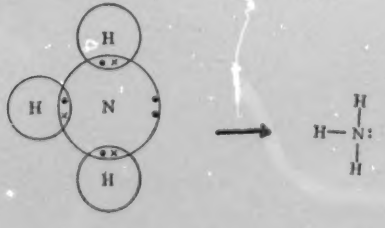
1. Metallic Bonding

These are the links that exist between the atoms of a metal. The atoms are packed closely together and the outermost electrons of each atom can move about freely in the metals. If opposite terminals are placed at the end of the metal the electrons are propelled in one direction thus electricity passes through that metal. Because of the metallic bond metals, unlike brittle salt crystals, can be drawn out into wires or threads. However, metallic bonds are strong bonds.

2. Co-ordinate Bond

In this type of bond, there is a similarity with covalent bonds except that there is an unequal sharing of electrons. One of the elements forming the bond provides more electrons to be shared. A good example of this type of bond is found where nitrogen joins with hydrogen to form ammonia NH_3.

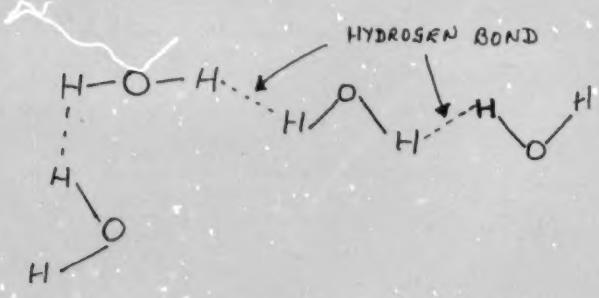
Two shared electrons are both supplied by one participating atom, in this case nitrogen.



Ammonia

3. Hydrogen Bond

This is a weak interaction between hydrogen atoms in a molecule of water.



In the experiment from Unit C1 where the pupils were studying the differences between a mixture and a compound, they first placed a magnet against a mixture of sulphur and iron filings, then against a compound of iron sulphide. They discovered that iron filings could be separated from the mixture, but the iron in the iron sulphide could not be attracted by the magnet, so separation could not occur.

EXPERIMENT 13 (a) Conduction of Electricity through a Solid page 54

(For the experiment 13 an ammeter can be used instead of bulbs.)

Pupils should observe that the light does not shine because naphthalene flakes and sugar possess covalent bonds while copper sulphate and calcium chloride crystals though formed by ionic bonding there are no free mobile ions present so the light does not shine.

EXPERIMENT 13 (b) Conduction of Electricity through a molten substance- page 54

This experiment should be done as Teachers Demonstration.

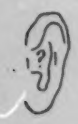
The bulb should shine when the crystals of sodium chloride or calcium chloride are melted as the ions become mobile in liquid therefore electricity passes through.

N.B.

Molten naphthalene flakes won't conduct electricity either because of the covalent bonds present.

EXPERIMENT 13 (c) Conduction of Electricity through a Solution page 54

The bulb will light when current is passed through the ionic solution only but not through sugar solution.



Through these three experiments the pupils should discover that it is only in ionic bonding that current electricity is conducted. For that to happen the ionic substance must be molten or in solution in order for the ions present to be mobile.

Exercise 5 page 55

1. How can an atom achieve a stable octet configuration?
2. Which shell of the atom is involved in chemical bonding?
3. Which particles in an atom take part in chemical bonding?
4. Name 3 possible ways by which atoms form a chemical bond?
5. (a) What do you call a particle that has gained an electron?
   (b) What do you call a particle that has lost an electron?

Answers to Exercise 5 page 55

1. It can either lose or gain electron(s) to have 8 or (2) in outer shell.
   It can also share electron(s) when forming covalent bonds.
2. Valency shell.
3. Valency electron(s).
4. (a) It can form an ionic bond with another atom i.e. lose an electron to a non-metal or vice versa - gain an electron from a metal.
   (b) It can share its valency electron(s) with another atom thus forming a covalent bond.
5. (a) A negative ion - Anion.
   (b) A positive ion - Cation.

Answers to Examination Questions page 56

E.Q.

1. (a) *Dissolve the crystal of sodium chloride in water and pass a current of electricity through it.*

The crystal could also be heated so it melts, then a current of electricity passed through it. Sodium atoms will collect at the cathode and chlorine gas will evolve from the anode if the crystal has been melted. But if a solution of sodium chloride is electrolysed hydrogen gas will evolve from the cathode and not sodium metal and at the anode chlorine gas will evolve.

This is because hydrogen is lower in the chemical reactivity series than sodium. Therefore hydrogen is displaced in water by sodium.

(b) *Electrovalent/ionic bonding makes very strong bonds so that in a solid a strong crystalline lattice is formed.*

(c) *Electrolysis of molten sodium chloride.*

(d) *Reacting sodium metal with water.*

Sodium metal reacts with water to form hydrogen and sodium hydroxide. The sodium hydroxide will be in solution so sodium ions will be present.

$$Na + H_2O \longrightarrow Na^+ (aq) + OH^- (aq) + H_2(g)$$

sodium atom water sodium ion hydroxyl ion hydrogen gas

2. (a) *Radioactivity.*

During radioactivity of the element uranium, the original uranium atom passes through the element radium as an intermediate and finishes as an atom of non-radioactive lead.

$$^{238}_{92}U \longrightarrow ^{226}_{88}Ra \longrightarrow ^{206}_{82}Pb$$

radioactive uranium. radioactive radium. non-radioactive lead.

The uranium atom loses 10 protons in all, reducing its atomic number by ten units. It also loses 32 units of atomic mass since 238 minus 206 equals 32 mass units and 92 minus 82 equals 10 protons.

Besides the protons lost, alpha particles (Helium ions) are emitted during the radio activity of uranium. Helium gas is therefore found with uranium ores.

(b) *Alpha particle which is a helium ion H^{++} - a particle possessing 2 protons and 2 neutrons.*

$$He \longrightarrow H^{++} + 2e$$

HELIUM ATOM HELIUM ION 2 ELECTRONS

(c) *A geiger-counter.*

This instrument detects radioactivity. The instrument gives a "blip" sound which increases in intensity as radioactivity increases.

3. (a) i. *These are particles found in the nuclei of atoms. They carry no charge and each has a mass of one unit.*

ii. *Radioactive means spontaneous decay or splitting of the nucleus of atoms of unstable elements resulting in emission of other particles.*

N.B. (b) * Errata page 57

Read radioactive instead of raioactive in that sentence.

Determining the age of very old geological specimens i.e. carbon dating.

Carbon isotopes are also used as tracers in organic reactions, e.g. to determine the intermediate products of photosynthesis or markers in the manufacturing industries.

(c) *By the use of a geiger-counter.*

4. (a) *Radioactive decay.*

(b) *Decrease in intensity of radioactivity is detected by a geiger counter.*

(c) *Heat from the reaction can be harnessed and used as happens in nuclear power stations.*

5. (a) *B*

B has 9 protons, therefore, as it is a neutral atom, it must have 9 electrons. It has 10 electrons and it has gained 1 electron to make it a negatively charged particle, i.e. anion, An anion moves towards an anode during electrolysis.

(b) *A and D*

A and D have the same atomic number but different mass numbers. D is the same atom as A except that D has 1 extra neutron in its nucleus.

(c) *C*

C needs one electron to make a stable Octet, and F has an electron which it can get rid of in order to leave a duplet. so F can transfer its electron to C easily.

(d) *alpha particles, neutrons*

These particles are emitted during radioactivity.

6. (a) *i: The half-life of an element is the time required for its radioactivity to fall by half from its observed value at a given moment.*

ii: NO because the half-life of carbon is too long - 5568 years.

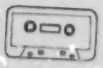
(b) *Original intensity of radioactivity = 14*
Half intensity of radioactivity $\frac{14}{2} = 7$

Time required to get to half radio activity of 7 is 3 years
Half life of element = 3 years.

(c) *i:* *Advantage. It's clean*

Nuclear power stations also do not use a lot of depletable resources like coal. With proper control there is no atmospheric pollution.

ii: *Disadvantage. Danger of leakage of radioactive materials into the environment. Without proper control, radioactive materials are dangerous to health. There is also a problem of disposal of the nuclear waste materials.*



Page 59 Casette-Programme SCRIPT

Please do the Examination Questions with the class first, before coming to the cassette programme and project.

How to use the casette programme.

You will find that if you play the whole casette programme (or read it) straight through, the pupils will get bored very easily, and become listless and so won't benefit from the extra information contained in the programme. At appropriate steps, stop the cassette programme and discuss with the class the relevant points raised in the cassette programme. The discussion should be of a general nature, but informative and relevant to the Atomic Theory.

Cassette Script. The Scientific Method.

Hello pupils. Now that you have been through Unit 2, we hope you know something now about particles and the structure of matter and the atomic theory.

Obviously your teacher has given you some information on the structure of the atom and you yourself have carried out a few experiments which might have helped to convince you about the existence of atoms and molecules, even though these are invisible to the naked eye. But is this really enough to make you believe in the Atomic Theory?

If you were in a research laboratory, with sophisticated equipment, you could have been shown the effects of electrons, protons and radioactivity. There is a limit, therefore, to the extent to which teachers can go in demonstrating effectively the existence of the particles of matter. Your teacher could neither show you electrons, protons and neutrons, nor would he demonstrate radioactivity to you. Nevertheless you will accept the theory of atoms and the structure of matter. Why is this? Is it because you have heard of the existence of atomic power stations and you also know about the destructiveness of atomic bombs etc.?

Imagine yourself as an ordinary person living around the end of last century. When there was a great debate on the nature of atoms and molecules, how much convincing would you have needed in order to accept the Atomic Theory? Would you have been easily convinced? What do you think? Remember what you learnt about trusting our senses in Unit A1.

Stop Cassette Programme. (Discussion with class 40

Cassette-Programme Discussion

Cassette-Programme Stop 1.

Ask the pupils to tell you why they would or would not be convinced easily of the existence of these particles if they were present during that period.

Many people could not be convinced of small particles of matter at that time because the evidence for their existence was lacking. There was no proof to show that atoms and molecules existed. Their effect could not be demonstrated convincingly until years later.

Continue Cassette Programme (after discussion).

We are sure you will agree with us if we say that it's difficult to make someone believe in things they cannot hear, see, touch or experience, or that are just too small to be seen.

Scientists working last century, before the invention of sophisticated equipment, had a lot of problems in convincing people about new ideas they had, or things they discovered.

Nonetheless, there is a way, or method, through which new ideas can be tested. We call this method the Scientific Method.

Man has always tried to find some explanation for the things that happen in nature. Very often in the past, there has been a tendency to believe something merely because a famous person has stated it to be true. This is against the Scientific Method. The Scientific Method is the willingness to abandon old ideas about things when new facts are discovered. From time to time scientists put forward an hypothesis. This is like an educated guess to explain something. Using the Scientific Method, the scientist then carries out a careful study of a subject, step by step, collecting and sorting out information. Once this has been done clear statements based on these observed facts can be given. These statements are called Laws.

Further experimenting and testing of these new laws results in the proving or disproving of the original hypothesis or guess. The simplest and most reasonable explanation of these laws results in the scientist putting forward a theory which makes clear the relationship between one fact and another or even one law and another. Such a theory is an imaginative set of ideas which link together a lot of apparently unrelated facts into one whole concept. Theory in science is therefore nothing but an hypothesis plus a proof. The theory must fit all the established facts and if a new fact becomes known which doesn't fit it, then the theory must be abandoned or changed to take account of it. A good example of this is the case of Aristotle, the famous Greek philosopher, who had stated 300 years before the birth of Christ, that heavy objects fall to the ground faster than light ones. For 2000 years no-one questioned this belief until someone in the 17th. century, (thought to be Galileo), performed a simple experiment to test the theory. A heavy object and a light object were dropped from a very high building, and it was observed that they reached the ground together!

Stop Cassette Programme. (Discussion with class

Cassette-Programme Stop 2.

Ask the pupils why a light object should fall at the same speed as a heavy object.

The answer is that the mass of a small object in comparison with a large object is not very different if compared to the mass of the earth, which is much, much bigger. Therefore the force of gravity exerts the same force on both objects and these fall at the same speed.

You can demonstrate this by placing a 5g mass and a feather on top of a book, then let all of them fall to the floor. The book, the 5g mass and the feather will reach the ground together.

If you let the feather and the 5g mass fall on their own, the 5g mass will reach the floor first. Air resistance will prevent the feather reaching the floor at the same time as the 5g mass because the mass of the feather is much smaller than that of the 5g mass. Also the feather has a large surface area through which air resistance can act.

Continue Cassette Programme (after discussion).

A number of theories, e.g. the atomic theory, the kinetic theory, the ionic theory and the electronic theory of valency, have been developed over the years by means of the scientific method.

The ideas about particles, i.e. atoms and molecules, have been put forward for more than a thousand years, as the ultimate units or building blocks of matter. Dalton formulated his atomic theory in 1567 but it was ignored for a long time until this century when physical proof of existence of atoms and other sub-atomic particles was provided by people like J.J. Thompson (1897) and Ernest Rutherford (1920). Thompson demonstrated the presence in matter of electrons and Rutherford showed how protons and electrons are arranged around the atom, through his experiments. Thanks to these two, and other like the Curies in Paris, who did a lot of work and experimentation with radioactive materials, we now accept the atomic theory as it stands today. Remember that theories are only the tools for work. If they are good they last a long time, and if they are bad they are replaced by better theories. It follows therefore that in science the value of a theory lies not so much in its truth, because no theory is ever regarded as the absolute or final truth, but rather as the nearest we can get to truth on the evidence so far available, which helps us to progress.

The combination of hand and head, of practical experiment and theoretical reasoning, is still perhaps the outstanding characteristic of the scientific method. It is through this method that the search for truth is carried out and finally arrived at.

END OF TAPE.

At the end of the cassette-programme put the following summary on the board and let pupils copy it into their note-books. Ask the pupils to write a paragraph on what they understand the scientific method to be.

Hypothesis - a supposition (educated guess) put forward to account for certain facts used as a basis for further investigation.

Law - factual statement of what always happens in certain circumstances.

Theory - set of ideas reasoned from known facts put forward to explain something.

PROJECT page 59

The success of this project depends upon you generating enthusiasm in the class to go and try out some of the things they have learnt in lessons. Naturally you will not get original or exciting ideas from everybody but you are bound to get some that are useful. These can be worked upon later and entered for Young Scientists Exhibition or sent to us here at Zim-Sci to get published in Teachers' Forum. Perhaps you could persuade your Headmaster to offer a prize for the best design?

Note that there is one very useful aspect to this project, and that is that it gives an opportunity to those who are not so skilled academically to apply what they have learnt and be appreciated for other talents (manual skills) that they may have.